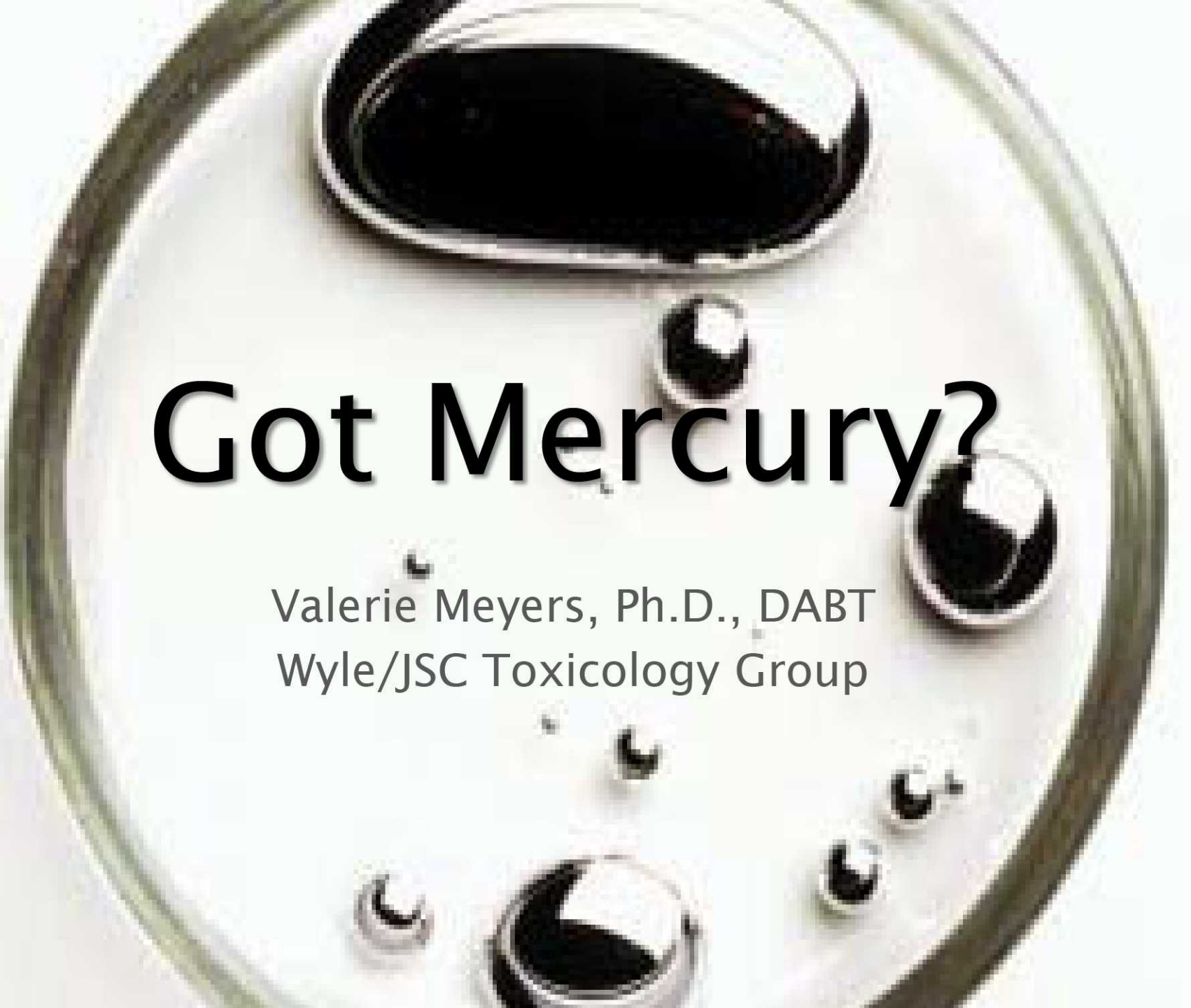


Got Mercury?

Valerie Meyers, Ph.D., DABT
Wyle/JSC Toxicology Group

Background

- Payloads and Systems components contain elemental mercury (Hg)
  - Lamps (metal halide, fluorescent)
  - Amounts range from ~2-30 mg Hg

- Current environmental control systems cannot remove mercury from the cabin atmosphere

Properties of Mercury

- Occurs in three primary chemical forms
  - Divalent (compounds and ions)
  - Organic compounds (methylmercury, ethylmercury)
  - Elemental

http://en.wikipedia.org/wiki/Mad_Hatter
http://www.grinningplanet.com/2004/08-10/mercury-in-fish-article.htm
http://en.wikipedia.org/wiki/Mercury_%28element%29

Properties of Mercury

- Liquid at room temperature
- Slightly volatile at room temperature
  - Volatility (vapor pressure) increases steeply as temperature increases
  - Insoluble in water

Exposure to Mercury

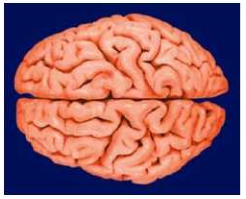
- Vapors are the primary health hazard
  - Readily passed into the bloodstream from inspired air
  - Accumulates in the brain and kidneys
  - Oxidized to the divalent form and eliminated primarily through feces and urine
    - Average ½ life is ~60 days in the human body

Acute Health Effects

- Respiratory irritation and inflammation
  - Cough, chest pain/discomfort, impaired pulmonary function
- Neuropsyciatric symptoms
  - Tremor, irritability, hyperactivity

Chronic Health Effects

- Central nervous system (CNS)



  - Tremor, decreased coordination
  - Erethism (irritability, excitability, loss of memory, loss of self-confidence, insomnia, and depression)
- Kidneys
  - Renal dysfunction (proteinuria, etc.)

http://www.morphonix.com/software/education/science/brain/game/specimens/wet_brain.html
med.stanford.edu/nephrology/community/

Current Spacecraft Maximum Allowable Concentrations (SMACs)

- 1-hour: 0.1 mg/m^3
- 24-hour: 0.02 mg/m^3
- 7-day: 0.01 mg/m^3
- 30-day: 0.01 mg/m^3
- 180-day: 0.01 mg/m^3

Safety Evaluation

- US Payload Safety Review Panel (PSRP) elected to consider release of elemental Hg a unique hazard
- Toxicology tasked with developing a non-hazardous limit

Considerations

- Single limit is insufficient
  - Different health endpoints for acute and chronic exposures
  - Chronic exposures possible since current ECLS systems cannot remove Hg
- Toxicology developed limits for exposures lasting 30 days or less and more than 30 days

Considerations

- Mercury Vapor Formation
  - Temperature dependent
    - Operating (heated) vs. stowed
    - Short-term vs. long-term exposure

Environmental Assessment and Risk Analysis Element

NJDEP

Research Project Summary

February 2004

Division of Science Research & Technology
Linking Science to New Jersey's Environmental Decision Making

Release of Mercury From Broken Fluorescent Bulbs

Michael Aucott[a], Michael McLinden[b], and Michael Winka[c]

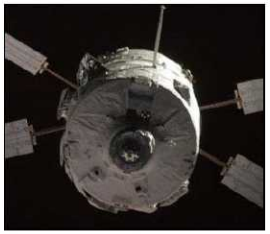
17-40% of 4.5 mg Hg contained in fluorescent bulbs volatilized in a sealed environment over a period of 2 weeks at temperatures ranging from 40-85°F.

Calculating Exposure Concentration

- Stowed items on manned vehicles when exposure is expected to occur for 30 days or less (Shuttle, Soyuz)
  - Total Hg x 40% ÷ total vehicle volume
- Operational (heated) items on manned vehicles when exposure is expected to occur for 30 days or less
  - Total Hg x 100% ÷ total vehicle volume

Calculating Exposure Concentration

- For unmanned vehicles (Progress,HTV, ATV)
  - Total Hg x 100% ÷ total vehicle volume



- For manned vehicles when exposure is expected to occur for more than 30 days (ISS)
  - Total Hg x 100% ÷ total vehicle volume

Final Recommendations

- Mercury vapor concentrations of 0.1 mg/m^3 or less for 30 days or less will not result in a critical or catastrophic toxicity hazard
- Mercury vapor concentrations of 0.01 mg/m^3 or less for more than 30 days will not result in a critical or catastrophic toxicity hazard